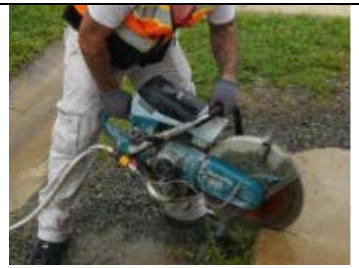
Silica Control Measures (Recalculated Table 1)

Required Engineering Controls and Respiratory Protection for Silica

The engineering controls and respiratory protection identified below must be used as the selection basis for work practices, controls, and personal protective equipment (PPE). However, if controls and PPE other than these are used, then exposure assessments must be conducted to demonstrate compliance with American Conference of Government Industrial Hygienists (ACGIH) threshold limit values (TLVs) per OPP 650-11 Silica Exposure Prevention and Control. The industrial hygiene (IH) program lead must use good IH judgment to determine when to periodically conduct confirmatory sampling of tasks conducted under this table. Use the highlighted links to Occupational Safety and Health Administration (OSHA) fact sheets for equipment listed in this table.

Key: APF = assigned protection factor.

Equipment/Use	Photo of representative equipment	Engineering and work practice control methods • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	NREL Respiratory Protection for compliance with ACGIH TLV of 25 µg/m³		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
1 **Handheld and Stand-Mounted Drills** (including impact and rotary hammer drills) [Per 29 CFR 1926.1153 c.1. vii]		https://www.osha.gov/Publications/silica/OSHA_FS-3630.pdf Use drill equipped with commercially available shroud or cowling with dust collection system. Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism. Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism. Use a high-efficiency particulate air (HEPA)-filtered vacuum when cleaning holes. Verify that: • The shroud or cowling is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; and • The dust collection bags are emptied to avoid overfilling.	None	None	APF 10
2 **Handheld Power Saws** (any blade diameter) [Per 29 CFR 1926.1153 c.1. ii]		https://www.osha.gov/Publications/silica/OSHA_FS-3627.pdf Use saw equipped with integrated water delivery system that continuously feeds water to the blade. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzle is working properly to apply water at the point of dust generation; • The spray nozzle is not clogged or damaged; • Hoses and connections are intact. When used outdoors:	None	APF 10	APF 25
		When used indoors or in an enclosed area (outdoor requirements above apply as well).	APF 10	APF 25	APF 25

Equipment/Use	Photo of representative equipment	**Engineering and work practice control methods** • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	**NREL Respiratory Protection** for compliance with ACGIH TLV of 25 µg/m^3		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
3 **Handheld Power Saws** for cutting fiber cement board (with blade diameter of 8 inches or less) [Per 29 CFR 1926.1153 c.1. iii]		https://www.osha.gov/Publications/OSHA3927.pdf For tasks performed outdoors only: Use saw equipped with commercially available dust collection system. Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency. Verify that: • The shroud or cowling is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions to prevent clogging; and • The dust collection bags are emptied to avoid overfilling.	None	None	APF 10
4 **Handheld Grinders** for mortar removal (*i.e.*, tuckpointing) [Per 29 CFR 1926.1153 c.1.xi]		https://www.osha.gov/Publications/silica/OSHA_FS-3632.pdf Use grinder equipped with commercially available shroud and dust collection system. Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism. Verify that: • The shroud is intact, encloses most of the grinding blade, and is installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; • The dust collection bags are emptied to avoid overfilling; • The blade is kept flush against the surface when possible; and • The tool is operated against the direction of blade rotation, when practical.	APF 10	APF 25	APF 50

Equipment/Use	Photo of representative equipment	**Engineering and work practice control methods** • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	**NREL Respiratory Protection** for compliance with ACGIH TLV of 25 µg/m^3		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
5 **Handheld Grinders** for uses other than mortar removal [Per 29 CFR 1926.1153 c.1.xii]		https://www.osha.gov/Publications/silica/OSHA_FS-3628.pdf Use a grinder equipped with integrated water delivery system that continuously feeds water to the grinding surface. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles are working properly and produce a pattern that applies water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact. Or use a grinder equipped with commercially available shroud and dust collection system. Dust collector must provide 25 cfm or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism. Verify that: • The shroud is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; and • The dust collection bags are emptied to avoid overfilling. For tasks performed outdoors only:	None	None	APF 10
		When used indoors or in an enclosed area (above conditions for outdoor tasks apply as well).	None	APF 10	APF 25
6 **Stationary Masonry Saws** [Per 29 CFR 1926.1153 c.1.i]		https://www.osha.gov/Publications/silica/OSHA_FS-3631.pdf Use saw equipped with integrated water delivery system that continuously feeds water to the blade. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzle is working properly to apply water at the point of dust generation; • The spray nozzle is not clogged or damaged; • Hoses and connections are intact.	None	None	APF 10

Equipment/Use	Photo of representative equipment	**Engineering and work practice control methods** • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	**NREL Respiratory Protection** for compliance with ACGIH TLV of 25 µg/m^3		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
7 **Jackhammers and Handheld Powered Chipping Tools** [Per 29 CFR 1926.1153 c.1.x]		https://www.osha.gov/Publications/silica/OSHA_FS-3629.pdf Use tool with water delivery system that supplies a continuous stream or spray of water at the point of impact. Verify that: • An adequate supply of water for dust suppression is used; • The water sprays are working properly and produce a pattern that applies water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact. When used outdoors:	None	APF 10	APF 25
		-When used indoors or in an enclosed area (conditions above for outdoor tasks apply).	APF 10	APF 25	APF 25
		Use tool equipped with commercially available shroud and dust collection system. Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism. Verify that: • The shroud is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; and • The dust collection bags are emptied to avoid overfilling. -When used outdoors.	None	APF 10	APF 25
		-When used indoors or in an enclosed area (conditions above for outdoor tasks apply).	APF 10	APF 25	APF 25

Equipment/Use	Photo of representative equipment	Engineering and work practice control methods • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	NREL Respiratory Protection for compliance with ACGIH TLV of 25 µg/m³		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
8 **Walk-behind Saws** [Per 29 CFR 1926.1153 c.1. iv]		https://www.osha.gov/Publications/silica/OSHA_FS-3633.pdf Use saw equipped with integrated water delivery system that continuously feeds water to the blade. (OSHA: <4hr- none; >4hr- none) Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles are working properly to apply water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact. When used outdoors:	None	None	APF 10
		When used indoors or in an enclosed area (conditions above for outdoor tasks apply).	APF 10	APF 25	APF 25
9 **Walk-behind milling machines and floor grinders** [Per 29 CFR 1926.1153 c.1.xiii]		https://www.osha.gov/Publications/OSHA3932.pdf Use machine equipped with integrated water delivery system that continuously feeds water to the cutting surface. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles are working properly and produce a pattern that applies water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact.	None	None	APF 10
		Use machine equipped with dust collection system recommended by the manufacturer. Dust collector must provide the air flow recommended by the manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism. Verify that: • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions to prevent clogging; and • The dust collection bags are emptied to avoid overfilling. When used indoors or in an enclosed area, use a HEPA-filtered vacuum to remove loose dust in between passes.	None	None	APF 10

Equipment/Use	Photo of representative equipment	Engineering and work practice control methods • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	NREL Respiratory Protection for compliance with ACGIH TLV of 25 µg/m^3		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
10 Drivable Saws [Per 29 CFR 1926.1153 c.1. v]		https://www.osha.gov/Publications/OSHA3928.pdf For tasks performed outdoors only: Use saw equipped with integrated water delivery system that continuously feeds water to the blade. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles produce a pattern that applies the water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact.	None	None	APF 10
11 Rig-mounted Core Saws or Drills [Per 29 CFR 1926.1153 c.1. vi]		https://www.osha.gov/Publications/OSHA3929.pdf Use tool equipped with integrated water delivery system that supplies water to cutting surface. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles produce a pattern that applies water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact.	None	None	APF 10
12 Dowel Drilling Rigs for Concrete [Per 29 CFR 1926.1153 c.1. viii]		https://www.osha.gov/Publications/OSHA3930.pdf For tasks performed outdoors only: Use shroud around drill bit with a dust collection system. Dust collector must have a filter with 99% or greater efficiency and a filter-cleaning mechanism. Use a HEPA-filtered vacuum when cleaning holes. Verify that: • The shroud is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; and • The dust collection bags are emptied to avoid overfilling.	APF 10	APF 25	APF 25

Equipment/Use	Photo of representative equipment	**Engineering and work practice control methods** • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	**NREL Respiratory Protection** for compliance with ACGIH TLV of 25 µg/m³		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
13 **Vehicle-mounted Drilling Rigs for Rock and Concrete** [Per 29 CFR 1926.1153 c.1.ix]		https://www.osha.gov/Publications/OSHA3931.pdf Use dust collection system with close capture hood or shroud around drill bit with a low-flow water spray to wet the dust at the discharge point from the dust collector. Verify that: • The shroud or hood is intact and installed in accordance with the manufacturer's instructions; • The hose connecting the tool to the vacuum is intact and without kinks or tight bends; • The filter(s) on the vacuum are cleaned or changed in accordance with the manufacturer's instructions; and • The dust collection bags are emptied to avoid overfilling.	None	None	APF 10
		Operate from within an enclosed cab and use water for dust suppression on drill bit. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles are working properly and produce a pattern that applies water on the discharge point from the dust collector; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact.	None	None	APF 10
14 **Small Drivable Milling Machines (less than half-lane)** [Per 29 CFR 1926.1153 c.1.xiv]		https://www.osha.gov/Publications/OSHA3933.pdf Use a machine equipped with supplemental water sprays designed to suppress dust. Water must be combined with a surfactant. Verify that: • An adequate supply of water for dust suppression is used; • The spray nozzles are working properly and produce a pattern that applies water at the point of dust generation; • The spray nozzles are not clogged or damaged; and • Hoses and connections are intact.	None	None	APF 10

Equipment/Use	Photo of representative equipment	Engineering and work practice control methods • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	NREL Respiratory Protection for compliance with ACGIH TLV of 25 µg/m³		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
15 **Large Drivable Milling Machines (half-lane and larger)** [Per 29 CFR 1926.1153 c.1.xv]		https://www.osha.gov/Publications/OSHA3934.pdf For cuts of any depth on asphalt only: Use machine equipped with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust.	None	None	APF 10
		For cuts of four inches in depth or less on a substrate: Use machine equipped with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust.	None	None	APF 10
		For cuts of four inches in depth or less on a substrate: Use a machine equipped with supplemental water spray designed to suppress dust. Water must be combined with a surfactant. Or use a machine equipped with supplemental water spray designed to suppress dust. Water must be combined with a surfactant. Operate and maintain machine to minimize dust emissions.	None	None	APF 10
16 **Crushing machines** [Per 29 CFR 1926.1153 c.1.xvi		https://www.osha.gov/Publications/OSHA3935.pdf Use equipment designed to deliver water spray or mist for dust suppression at crusher and other points where dust is generated (e.g., hoppers, conveyers, sieves/sizing or vibrating components, and discharge points). OSHA: <4hr- none; >4hr- none Use a ventilated booth that provides fresh, climate-controlled air to the operator, or a remote-control station. Verify that: • Nozzles are located upstream of dust generation points and positioned to thoroughly wet the material; • The volume and size of droplets is adequate to sufficiently wet the material (optimal droplet size is between 10 and 150 µm); and • Spray nozzles are located far enough from the target area to provide complete water coverage but not so far that the water is carried away by wind.	None	None	APF 10

Equipment/Use	Photo of representative equipment	Engineering and work practice control methods • Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions. • Operate and maintain machine to minimize dust emissions	NREL Respiratory Protection for compliance with ACGIH TLV of 25 µg/m³		
			<2hr./ shift	2-4 hr./ shift	>4 hr./ shift
17 **Heavy Equipment and Utility Vehicles** used to abrade or fracture silica-containing materials (*e.g.*, hoe-ramming, rock ripping) or used during demolition activities involving silica-containing materials [Per 29 CFR 1926.1153 c.1.xvii]		https://www.osha.gov/Publications/OSHA3936.pdf Operate equipment from within an enclosed cab. When workers outside the cab are engaged in the task, apply water and/or dust suppressants as necessary to minimize dust emissions.	None	None	APF 10
18 **Heavy Equipment and Utility Vehicles** for tasks such as grading and excavating but not including: Demolishing, abrading, or fracturing silica-containing materials [Per 29 CFR 1926.1153 c.1. xviii]		https://www.osha.gov/Publications/OSHA3937.pdf Apply water and/or dust suppressants as necessary to minimize dust emissions or	None	None	APF 10
		When the equipment operator is the only worker engaged in the task, operate equipment from within an enclosed cab.	None	None	APF 10

When implementing the control measures specified in the table, each worker must:

- For tasks performed indoors or in enclosed areas, provide a means of exhaust as needed to minimize the accumulation of visible airborne dust.
- For tasks performed using wet methods, apply water at flow rates adequate to minimize the release of visible dust.
- For measures implemented that include an enclosed cab or booth, verify that the enclosed cab or booth:
  - Is maintained as free as practicable from settled dust
  - Has door seals and closing mechanisms that work properly
  - Has gaskets and seals that are in good condition and working properly
  - Is under positive pressure maintained through continuous delivery of fresh air
  - Has intake air that is filtered through a filter that is 95% efficient in the 0.3-10.0 µm range (e.g., minimum efficiency reporting value of 16 or better); and
  - Has heating and cooling capabilities.
- Where a worker performs more than one task on the table during a shift, and the total duration of tasks combined is more than four hours, the required respiratory protection for each task is the respiratory protection specified for more than four hours per shift. If the total duration of tasks in the table combined is less than four hours, the required respiratory protection for each task is the respiratory protection specified for less than four hours per shift.

Basis for NREL Adopted Respiratory Protection APF

The NREL adopted APF modifies the OSHA APF for compliance with the ACGIH TLV of 25 µg/m^3. OSHA permissible exposure limit (PEL) is used to back calculate the maximum concentration associated with the controls listed—time, respirator, or time and respirator. Choose the concentration associated with the same controls when performing the calculation to achieve 25 µg/m^3.

For tasks where OSHA did not restrict exposure duration (time) or require respirators, assumed maximum concentration is 50 µg/m^3. This applies to row one (green row) tasks. Equations reflect control fir time first (divide by 4 or 2), then a second division for respirator.

Note:
Division by 2 accounts for four-hour exposure duration versus the PEL-based eight-hour exposure.
Division by 4 accounts for two-hour exposure duration.
Division by 10, 25, or 50 accounts for the respirator APF reduction.

OSHA PEL = 50 µg/m^3			**ACGIH TLV = 25 µg/m^3**			**OSHA Table 1 Tasks**
≤ 4 hours/shift	> 4 hours/shift		≤ 2 hours/shift	≤ 4 hours/shift	> 4 hours/shift	
None*	None*		None	None	APF 10	3,4,5, 12 outdoors, 1, 6, 7, 9 13, 14, 15, 16, 17, 18
50 µg/m^3	**50 µg/m^3**		50/4 = 12.5	50/2 = 25	50/10 = 5	
None (time only)	APF 10 (respirator only)		None	APF 10	APF 25	2 outdoors, 10 outdoors, 12 indoors/enclosed
100-2 = 50 **100 µg/m^3**	500/10 = 50 **500 µg/m^3**		100/4 = 25	100/2 – 50 500/2/10 = 25	500/10 = 50 500/25 = 20	
APF 10 (time and respirator)	APF 10 (respirator only)		APF 10	APF 25	APF 25	2 indoors/enclosed 4 indoors/enclosed 8 outdoors 10 indoors/enclosed
1000/2/10 = 50 **1000 µg/m^3**	500/10 = 50 **500 µg/m^3**		1000/4/10 = 25	1000/2/10 = 50 APF 10 not protective enough 1000/2/25 = 20	500/10 = 50 500/25 = 20	
APF 10 (time and respirator)	APF 25 (respirator only)		APF 10	APF 25	APF 50	11
1000/2/10 = 50 **1000 µg/m^3**	1250/25 = 50 **1250 µg/m^3**		1000/4/10 = 25	1000/2/10 = 50 1000/2/25 = 20	1250/25 = 50 1250/50 = 25	

In the Preamble to 29 CFR 1925.1153 in the Federal Register Vol. 81, No. 58 (pages 16461-16463), OSHA discussed the adequacy of use of 29 CFR 1925.1153c.1 Table 1 for compliance with the OSHA action level of 25 µg/m^3. The OSHA table does not ensure compliance with 25 µg/m^3. The OSHA action level and the ACGIH TLV are both 25 µg/m^3, thus this comparison is appropriate to be used for U.S. Department of Energy-mandated ACGIH TLV. To address the lower TLV value, when OSHA's Table 1 provided an APF, NREL has reduced the exposure time or increased the APF value as necessary to stay within the 25 µg/m^3 TLV. For instance, if the OSHA Table 1 listed APF = 10, NREL set the APF = 25-50 to stay within the TLV. When OSHA listed "None" for eight hours, NREL may have adopted APF = 10 as needed. NREL added the <2 hour/shift column to allow safe exposure without respiratory protection when possible.

0716/2019